Effect of Saline Water on Geotechnical Properties of Low Plastic Soil and High Plastic Soil

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Bachelor of Technology in Civil Engineering

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May 11, 2015

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Declaration

I Hereby Declare That This Thesis Is My Own Work And Effort. Throughout This Documentation Wherever Contributions Of Others Are Involved, Every Endeavour Was Made To Acknowledge Clearly With Due Reference To Literature. This Work Is Being Submitted For Meeting The Partial Fulfilment For The Degree Of Bachelor Of Technology In Civil Engineering At National Institute Of Technology, Rourkela For The Academic Session 2011 2015..

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Certificate

This is to certify that the thesis entitled **"Effect of Saline Water on Geotechnical Properties of Low Plastic Soil and High Plastic Soil "** submitted to the National Institute of Technology, Rourkela by **Rudrendra Kashyap, Roll Number-111CE0592,** for the award of the Degree of Bachelor of Technology in Civil Engineering Engineering is a record of bona fide research work carried out by then under my supervision and guidance. The results presented in this thesis has not been, to the best of my knowledge, submitted to any other University or Institute for the award of any degree or diploma. The thesis, in my opinion, has reached the standards fulfilling the requirement for the award of the degree of Bachelor of technology in accordance with regulations of the Institute.

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Acknowledgement

I have given efforts in the project. But certain individual and department have helped me in finishing this project.This project wont be possible without the assistance of Dr. R.Bag , my supervisor .I also would like to thank my friends and family for helping me.

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Abstract

In this research, the effect of water salinity on geotechnical properties of fine grained soil of Roukela and Bikaner clay was studied. In the Laboratory, several tests such as Atterberg limit test were done with distilled water and water of different concentration of Nacl. Results on Roukela soil show that both liquid limit and plastic limit decreases with increase in salinity. Increase in salinity increases optimum moisture content and decreases maximum dry density.Results on Bikaner clay show that Liquid limit decreases with increase in salinity.

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1 Introduction

The chemistry of Pore Liquid effects the Geotechnical properties of soil.From sea water intrusion or from the leachate coming out from rocks containing several mineral saline water enters into in-situ soil. For the proper understanding of the behaviour of soil when reacted with saline water ,it must be mixed in proper concentration and their effect on the geotechnical properties of soil must be studied.

Bentonite has certain properties like ease of dispersion in water,viscosity,thixotropy and low permeabilty, because of which it is used as drilling liquid.Bentonities $(4-8\%)$ are used in grouting fissures in rock slurries.To provide non-mechanical support to the wall of trecnhes,during pilling and in other excavation,it is used in diaphgram.It is also used to lubricate caissions and piles. For soft ground tunnelling and to increase the pumpability of concrete, bentonites are used. Bentonite then be excavated and the bentonite suspension separated and recycled for further use. Only sodium bentonite is suitable for these applications. Natural sodium-bentonites and sodium-exchanged calcium bentonites are used to improve the performance of clay liners in engineered landfill sites for solid and liquid waste [1].

The present method used for landfill is to contain and treat leachates so that to provide protectionto nearby aquifers and/or discharges to surface water courses, rather than dilute and disperse as in the past. Clay liners are sandwitched between plastic geomembrane and have have maximum hydraulic conductivities of$10-9m/s$ (UK) or $10-6m/s$ (USA) . Some natural clays may be acceptable for this purpose, although the use of bentonite is increasing since the consistency and high-swelling capacity of this clay allows for a much thinner lining. Natural clay liner performance is improved by rotovating-in bentonite granules to produce a compacted bentonite-enriched soil [2]. Alternatively, bentonite may be incorporated in a geocomposite fabric. This material is easy to lay, flexible and has low permeability. It also has the ability to self-seal if punctured.

Sodium bentonites used for landfill liners are generally treated with a polymer (anionic polyacrylamide) to prevent flocculation where solute concentrations in leachates are likely to be high $(> 100ppm)$. Much research is being conducted at present into the possible use of compacted sodium bentonite as backfill in radioactive waste repositories [3]. The main properties relevant to this application are the low hydraulic conductivity of the compacted bentonite (which isolates the radioactive waste canisters from circulating groundwater) and the cation-exchange capacity (to capture any radionuclides escaping from the canisters).

1.1 Atterberg limits

Atterberg limits are basically Liquid limit,Plastic limit and Shrinkage limit. Bonding properties of Bentonite is indicated by Liquid limit. It is the minimum % water that will cause a bentonite-water mixture to flow when tested in prescribed manner using the Casagrande liquid limit apparatus, or the percentage of water relating to a penetration depth of 20*mm* using a cone penetrometer. Figure 1 (a) & (b) show the Casargrande apparatus and Cone penetrometer, respectively. The LL test can be a sensitive indicator of the response of a Ca, Mg-bentonite to sodium exchange.

(a) Casargrande apparatus

(b) Cone penetrometer

Figure 1: Atterberg limits testing equipments

Based on the data we obtained from liquid limit and plastic limit tests change in different states of soil from liquid to solid state is determine.Figure 2 shows various states of soil with change in water content. A saturated slurry soil when dried gradually, it reached semi-solid and then solid state. The LL of a bentonite can form part of the specification for foundry use and is commonly mentioned on specification sheets of bentonites offered for many other applications. Generally, Ca-bentonites give in the range 100 – 200 and Na-bentonites values between 550 and 750. In the higher range, LL values are markedly affected by the method of preparation used. The LL test can be a sensitive indicator of the response of a Ca, Mg-bentonite to sodium exchange.

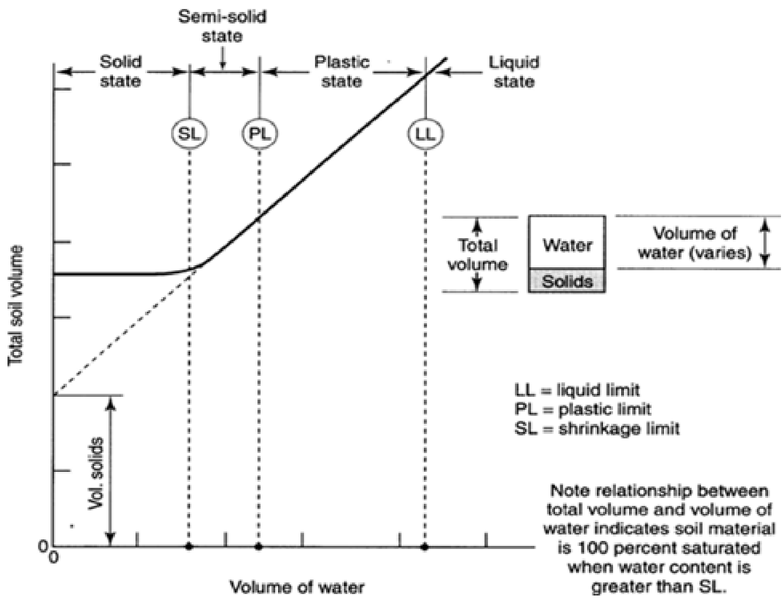

Figure 2: Curves showing transition stages from liquid state to solid state (after Murthy, 1993)

1.2 Compaction characteristics of soil

Proctor Compaction test was originally developed to mimic field compaction in the lab. The aim of the test was to find the optimum moisture content at which the maximum dry unit weight is attained. For a given soil and water content the best possible compaction is represented by the zero-air-voids curve.. For dry soils the unit weight increases as water is added to the soil because the water lubricates the particles making compaction easier. As more water is added and the water content is larger than the optimum value, the void spaces become filled with water so further compaction is not possible because water is a kind like incompressible fluid.

As water is added to a soil at low moisture contents, it becomes easier for the particles to move past one another during the application of compacting force. As the water content increases, the soil particles develop larger water films around them.

In the current study soil from Rourkela and a bentonite known as Bikaner clay was used to study how Geotechnical properties of soil is affected by Salinity. The salinity of sea water is about 0.6M NaCl solution. Therefore, NaCl solutions of varying concentrations were used in order to simulate higher and lower salinity levels in soil.

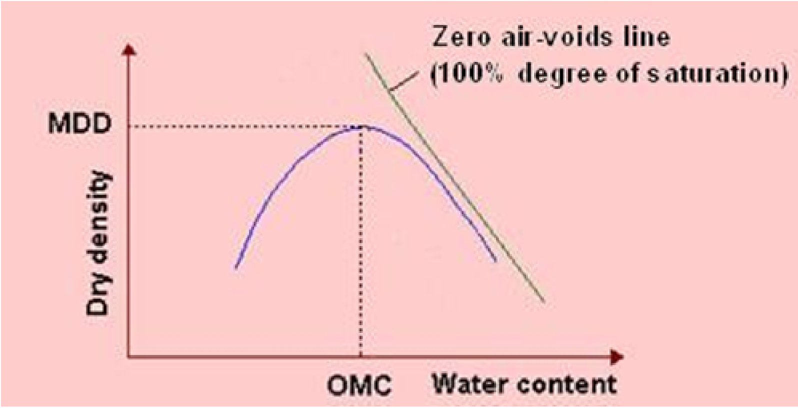

Figure 3: Typical compaction curve showing relation between dry density and water content of soil.

2 Literature Review

Bentonite is a clay whose chief constituent is Montmorillonite,one of the common mineral of the Smectite group. A schematic diagram of montmorillonite is shown in figure 4. A unit layer of montmorillonite consists of one aluminium octahedron sandwiched between two Silica tetrahedron sand. The higher valency cations are being substituted by lower valence cations. This leaves unsatisfied negative charges, which are balanced by loosely-held exchangeable cations such as Na+, Ca2+, Mg2+ and H+ located mainly on the interlayer crystal surfaces. Bentonite has certain unique properties like surface area which is chemically active,high cation-exchange capacity,unusual hydration characteristics and its tendency to effect flow behavior of liquids.These properties arises because od its chemical composition,exchangeasble ion-type and small crystal size of Smectite [4].

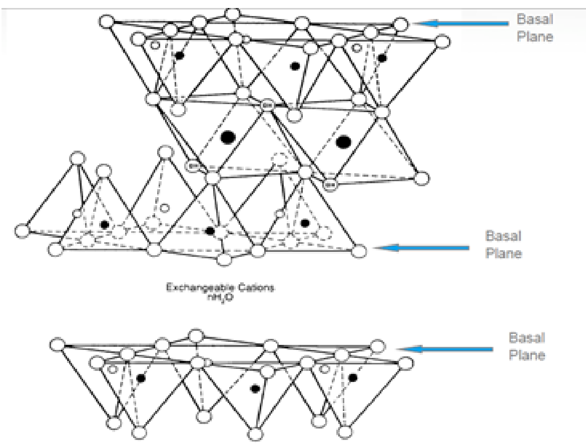

Figure 4: Structure of montmorillonite (Mitchell, 1993)

Bentonite has certain properties like its tendency to form thixotropic gels with water,tohave very large cation exchange capacity and to absorb water(large amount). Several researchers have studied how swelling is effected by salinity and other properties of bentonite [3, 5–7].

There is limited literature available on the effect of salinity on Indian soil. Therefore, objective of the this particular study is to study the effect of salinity on Atterberg limits and compaction characteristics of two different soils.

3 Methodology

In the current study two different soils were used. One is Rourkela soil and the other one a bentonite known as Bikaner Clay. The bentonite power was supplied by Raj Minerals, Bikaner. The liquid limit and plastic tests were conducted by following IS code.

3.1 Procedure for determination of liquid limit and plastic limit

Clay water mixtures of both soils were prepared by thoroughly mixing clay powders with distilled water and NaCl solutions. Clay-water mixtures were kept in sealed plastic container for 24 hours in order to allow clay- water mixture to equilibrate properly. After 24 hours clay-water mixtures were remixed and used for determining liquid limit by Casargrande apparatus. Both Rourkela soil and Bikaner clay were mixed with distilled water as well as 0.1M, 0.5M and 1.0M NaCl solutions. Liquid limit tests were conducted using Casargrande apparatus.

Plastic limit tests were carried by rolling the soil-water mixture in between palms until the thickness of thread become 3mm and it starts to crumble on the surface. The water content at that point was measured.

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Plastic limit tests were carried by rolling the soil-water mixture in between palms until the thickness of thread become 3*mm* and it starts to crumble on the surface. The water content at that point was measured.

3.2 Proctor compaction test

Clay water mixtures with different water contents were mixed with Rourkela soil and both,Standard Proctor test and Modified proctor test was performed to find out Optimum moisture content and Maximum dry density with distilled water and with 0.1M,0.5M and 1M Nacl solution.

4 Results and Discussion

4.1 Results of Low Plastic Soil of Rourkela

Table 2 shows the results of liquid limit, plastic limit compaction test. The test results with and plastic index values by using three types of water. Plastic limits with distilled, 0.1, 0.5 and 1.0M NaCl are 16.56, 16.28, 16.28 and 16.13, respectively. Plastic Limit is not very influenced by salinity i.e effect is not very large. Soil having higher moisture content , the effect of salinity on liquid limit will be more appreciable .With increase in salinity of water ,Optimum moisture content increases but Maximum dry density decreases.

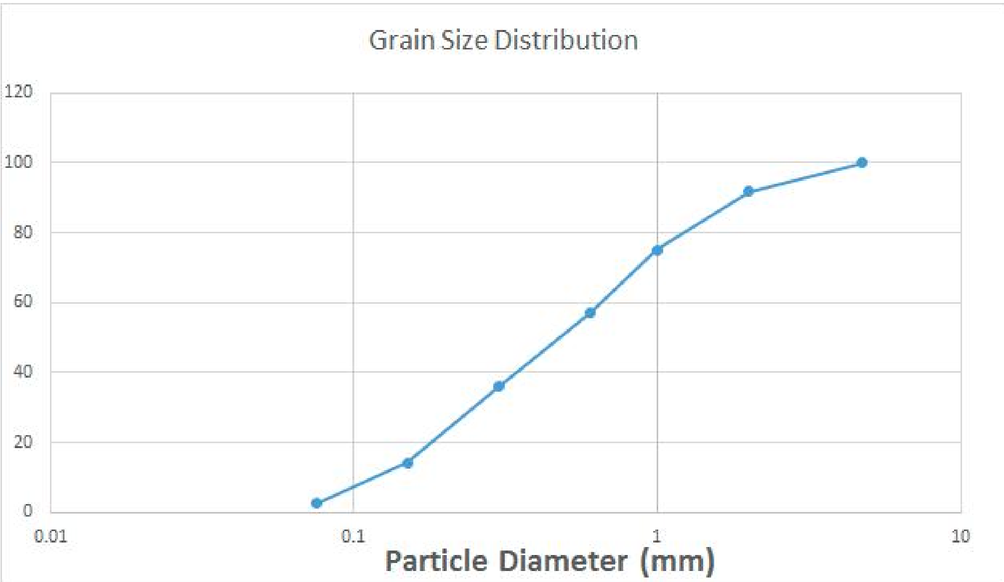

Figure 5: Grain Size Distribution Plot

Properties of Roukela Soil when Salinity is nill	vaule
Liquid Limit	30
Plastic Limit	16.6
Specific Gravity	2.6

Table 1: Results of Low plastic Soil of Rourkela without salinity

Compound under Test	Liquid Limit($\%$)	Plastic Limit ($\%$)	Optimum Moisture Content ($\%$)	Maximum Dry Density (mg/m^3)
Distilled water	29.7	16.6	9.3	1.82
0.1 M NaCl	27.6	16.4	9.6	1.82
0.5 M NaCl	26.4	16.3	10.2	1.81
1.0 M NaCl	24.5	16.1	10.6	1.81

Table 2: Results of Low plastic Soil of Rourkela with salinity

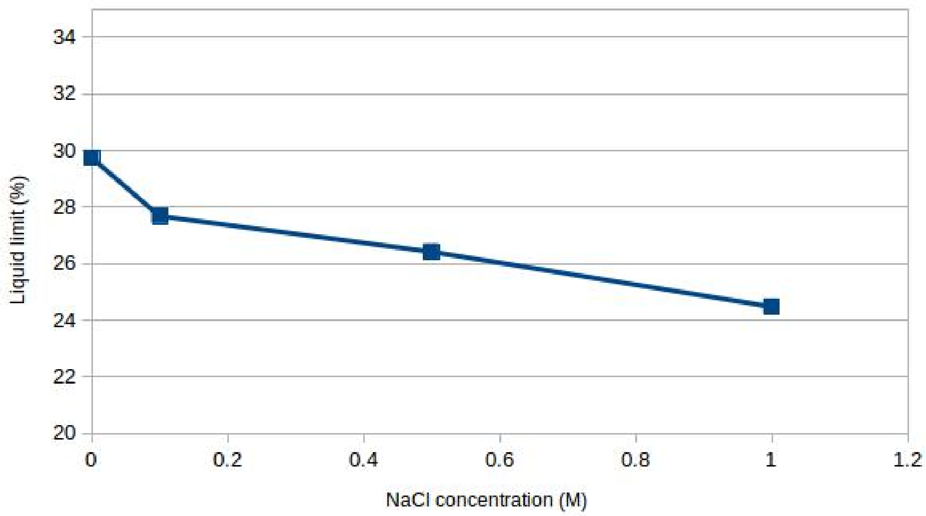

Figure 6: Variation of Liquid limit with change in NaCl solution concentration

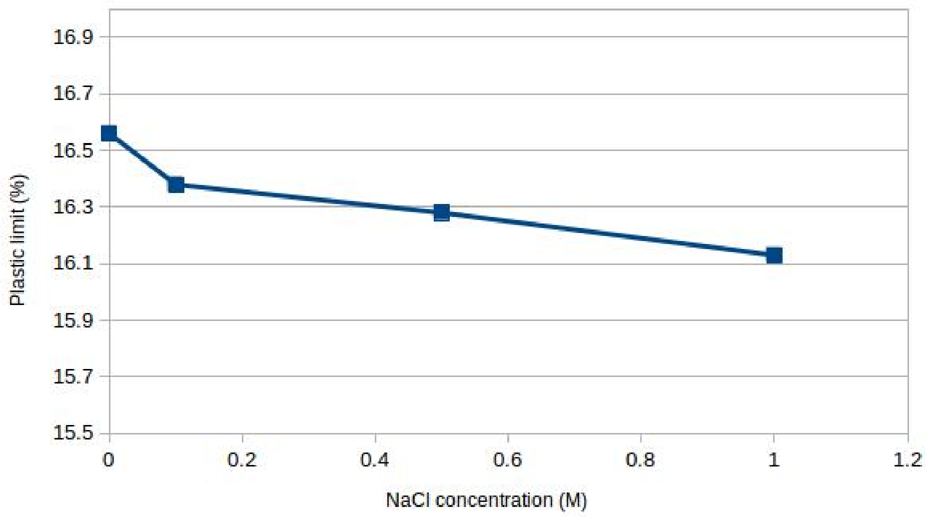

Figure 7: Variation of plastic limit with change in NaCl solution concentration

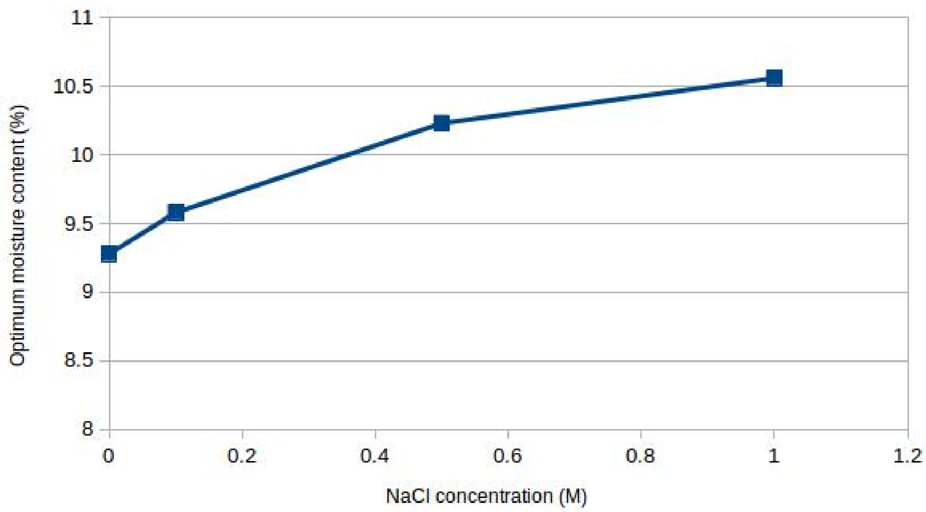

Figure 8: Variation of OMC with change in NaCl solution concentration

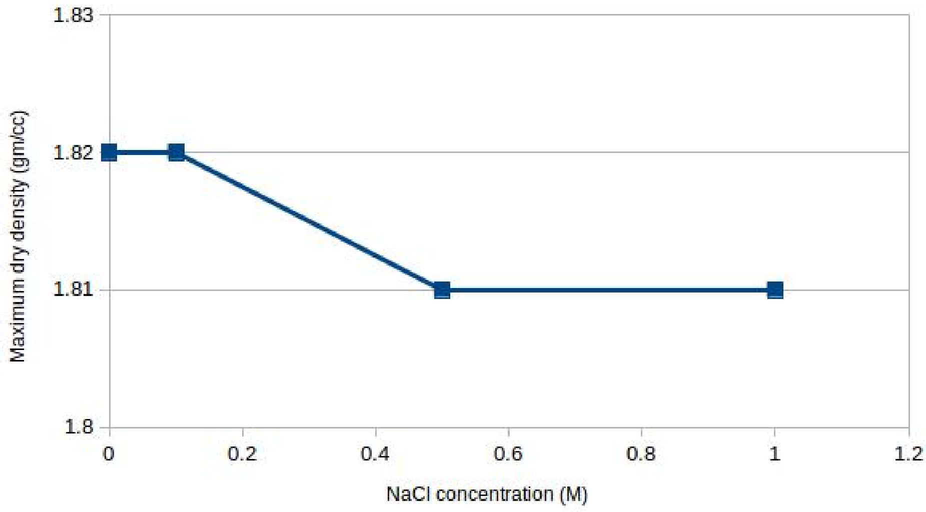

Figure 9: Variation of MDD with change in NaCl solution concentration

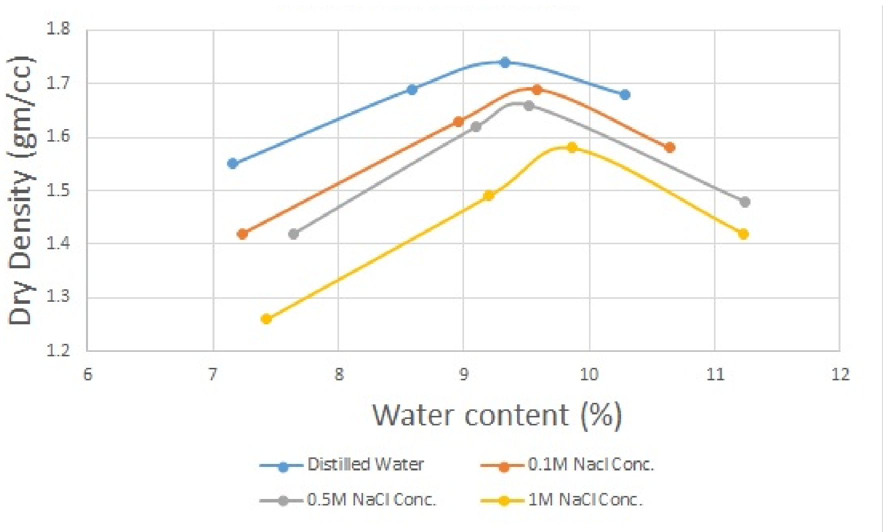

Figure 10: Dry density vs Water content relationship obtained using Distilled water and NaCl solution during Standard Proctor Compaction Test

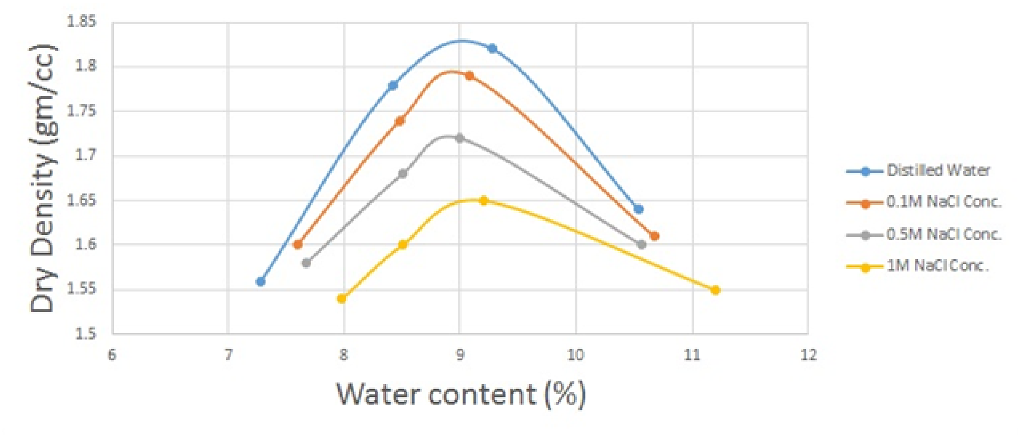

Figure 11: Dry density vs Water content relationship obtained using Distilled water and NaCl solution during Modified Proctor Compaction Test

4.2 Results of Bikaner clay

Liquid limit of Bikaner clay was found to be decreased from 375% to 190% when concentration of NaCl is increased from 0% to 3% $(0.53M)$. After this, the decrease in liquid limit up to 10% $(1.80M)$ NaCl was not significant.

Properties of Bikaner Clay	Value
Liquid Limit	370
Plastic Limit	55

Table 3: Results of Bikaner Clay

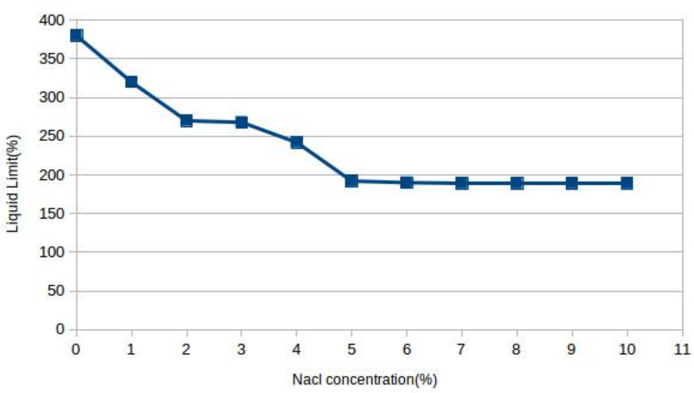

Figure 12: Change in the Liquid Limitwith change in NaCl solution concentration

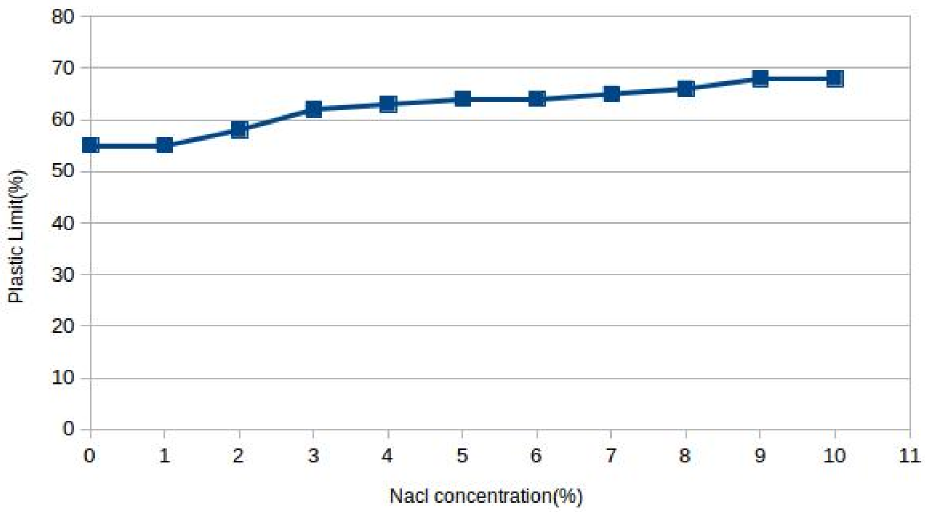

Figure 13: Change in the Plastic Limit with change in NaCl solution concentration

5 Conclusion

Following are the Conclusions drawn from the results obtained:

- Increase in concentration of NaCl solution liquid limit and plastic limit of both soils were found to be decreased.
- Increase in concentration of NaCl solution increased OMC and deceased MDD of Rourkela soil. However, when NaCl solution was added more than 0.5 M the MDD was found to constant.

6 Scope of Future Work

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